INFLUENCE OF AGRONOMIC GRASS-LEGUME MIXTURES ON THE PERFORMANCE OF COMMERCIAL SOFTWOOD TREE SPECIES USED IN RECLAMATION

1980 Progress Report

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Abstract

The progress report presents the first year results of a study examining the effects of agronomic grass-legume mixtures and application rates on the performance of commercial softwood tree species. The relevant literature on grass-legume erosion control and competition with tree species is reviewed.

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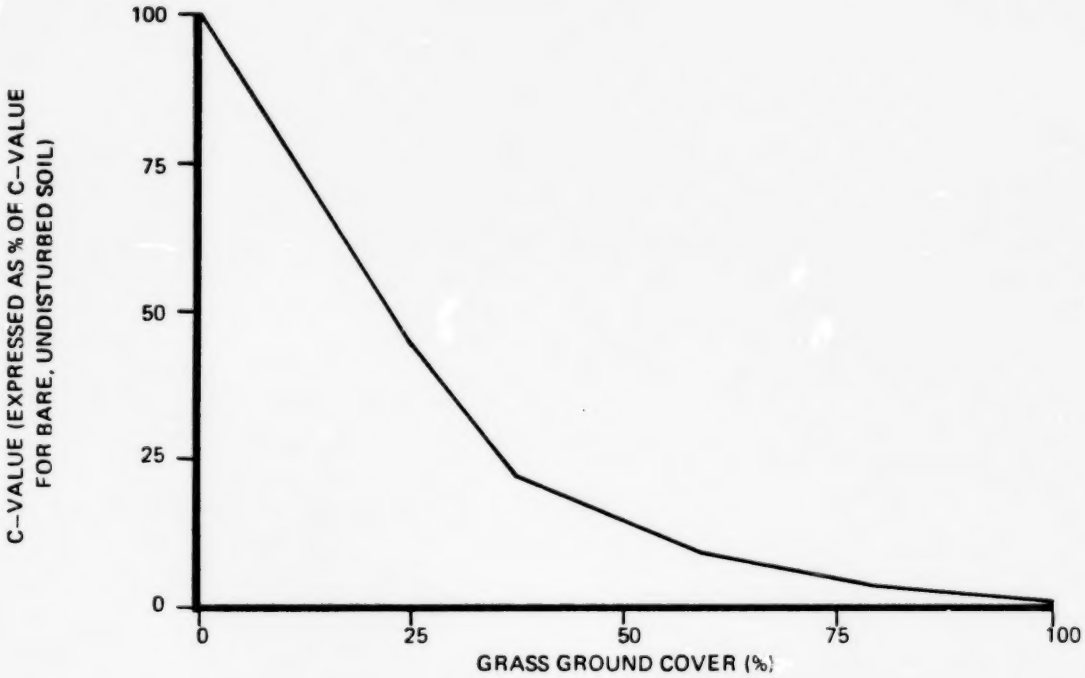
1.0 INTRODUCTION

On disturbed, critical sites agronomic grass-legume mixes are necessary to obtain erosion control. However, the resulting vegetative cover may be detrimental to attaining a post-reclamation forestry land use. One of the most significant influences exerted by the herbaceous, erosion-controlling component may be excessive competition with interplanted trees. A method of adequately controlling erosion while reducing intraspecific grass-legume and tree competion is a crucial need in meeting both short and long term land rehabilitation objectives.

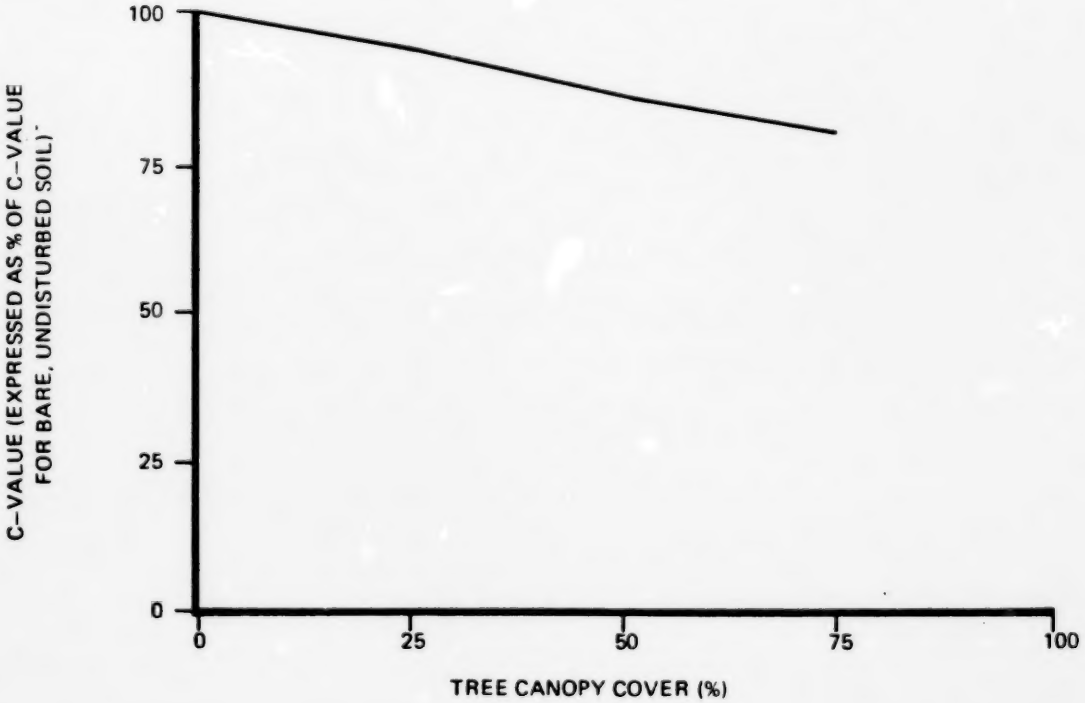
Grasses or grass-legume mixes are very effective in reducing losses of soil by water erosion. Figure 1A demonstrates that complete ground cover diminishes erosion to a negligible level and that even partial covers may substantially reduce soil loss. The latter is in general agreement with other published information. On sloped, forest roadsides in British Columbia ground covers of 61-66% reduced erosion from 2.3 cm (for unseeded slopes) to less than 1.6 cm (Carr and Ballard, 1980). Increases in cover from 5-15 percent to 90-95% decreased soil loss by 91-113 percent (Dyrness, 1970) and substantial reductions in

FIGURE 1 – EFFICACY OF VEGETATION COVER TYPES IN REDUCING SOIL EROSION (DERIVED FROM : WISCHMEIER, 1974)

A) GRASS COVER (AT GROUND SURFACE)



B) TREE CANOPY COVER (EFFECTIVE HEIGHT OF 4m, NO VEGETATION AT GROUND SURFACE)



erosion were accomplished with 80 percent herbaceous cover (Dyrness, 1975). An increase in grass-legume pasture herbage from less than 2.2 to 5.6 t/ha reduced Universal Soil Loss Equation cropping factors from 1.0 to 0.4 (Wischmeier, 1960).

The use of trees alone is inadequate for erosion control (Figure 1B). On disturbed soils in Idaho, Megahan (1974) estimated that six-year-old ponderosa pine would have to be planted at densities of up to 11,900 trees per hectare to produce a one-third reduction in soil loss: seedling densities which would be unacceptable for forest management. The efficiency of trees in controlling erosion is dependent on raindrop impact velocity which in turn is directly related to canopy density and the height of the canopy from the ground (Geiger, 1965).

Combinations of tree and up to 60 percent grass cover were generally more effective in erosion control than grass cover alone (Table 1). It is noteworthy that ground covers of 80-100 percent were as or more efficaceous than that amount of ground cover plus tree canopy cover. This may be attributed to the capacity of dense ground covers to dissipate rainfall impact regardless of whether canopy cover has reduced rainfall velocity (Wischmeier, 1974).

Mixtures of grasses and loblolly pine have been used for erosion control in the south-eastern United States (Duffy, 1974). Rapidly developing grass species provided satisfactory ground cover for erosion prevention but competitively overwhelmed the pine seedlings. Relatively slow-growing

Table 1. Cover Factor (C) Values For Permanent Pasture And Forested Land
(From: Wischmeier, 1974)

Type of Raised Vegetation Canopy	Effective Canopy Height (m)	Canopy Cover (%)	C Value (by Percent Surface Ground Cover[1])					
			0	20	40	60	80	95-100
None		0	0.450	0.200	0.100	0.420	0.012	0.003
Trees	4.0	25	0.420	0.190	0.100	0.041	0.013	0.003
		50	0.039	0.180	0.090	0.040	0.013	0.003
		75	0.360	0.170	0.090	0.390	0.013	0.003

[1]Cover at surface is grass

grasses were less competitive with the trees but sacrificed ground cover during the first several years. Therefore, it would appear that a mixture of slow and quickly developing grasses would be desirable in combination with tree planting and erosion control.

On spoil areas in Tennenssee, methods of establishing pitch and Virginia pines in association with grasses were investigated (Hay and Woods, 1980). On grass cover treatments the second year survival of both tree species had reached unacceptably low levels and were significantly lower than on the bare control. Virginia pine height and diameter growth were suppressed on grassed areas. The investigators concluded that successful establishment of these pines, and Virginia pine in particular, was dependent upon minimizing the competitive effect of grass cover through reductions in seeding rate.

Baron (1962) reported a species-dependent relationship between various grasses and the survival of planted ponderosa pine seedlings. Orchardgrass (Dactylis glomerata), tall oatgrass (Arrhenatherum elatius), perennial ryegrass (Lolium perenne), and timothy (Phleum pratense) treatments reduced the third year tree survival relative to ungrassed controls. In plots sown to big bluegrass (Poa ampla), pubescent wheatgrass (Agropyron trichophorum), hard fescue (Festuca ovina var. duriuscula) or redtop (Agrostis alba) survival was greater than in the controls. Similar effects have been observed between Koeleria cristata, Calamagrostis canadensis, Andropogon gerardii, and Pinus banksiana and Picea glauca and in part may be attributed

to grass form and habit (Sims and Mueller-Dombois, 1968). Appendix I summarizes the literature for the species used in the experiment described herein.

Grass density had a significant, inverse effect on early lodgepole pine height growth and seedling weight while having no effect on survival (Clark and McLean, 1979). A pronounced, inverse relationship occurred between survival of lodgepole pine and white spruce and grass-legume aboveground biomass while there appeared to be a similar relationship between survival and the amount of grass-legume cover on amended lean tailings sand (Fedkenheuer et al, 1980). Grass density affected the height performance of white spruce (Sims and Mueller-Dombois, 1968).

The study reported herein was initiated in 1979 to determine the effects of grass-legume seed mix composition and application rates on the performance of interplanted lodgepole pine and white spruce. Additional project objectives include:

i) studying the performance of the grass-legume treatments,

ii) evaluating the erosion control potential of the plant covers and,

iii) defining the optimal balance between agronomic cover erosion control and competitive effects on trees.

2.0 METHODS

2.1 LOCATION

The experimental was established at two sites: LS 10-Sec 16-Twp 6-Rge 4-W5M (Lynx Creek, Southern Foothills) and LS 6-Sec 21-Twp 46-Rge 18-W5M (Fairfax Lake, Central Foothills).

2.2 DESIGN

At each site a 2X4X2 factorial experiment in randomized complete blocks was established. Treatments included 2 seed mixtures, 4 seed mixture application rates, and 2 tree species. Each treatment was replicated three times.

The seed mixture treatments are given in Table 2. Seed mixture application rates were 0.0, 8.4, 16.8, and 28.0 kg/ha (0.0, 7.5, 15.0 and 25.0 lbs/ac respectively). The tree species used were lodgepole pine and white spruce planted as 2-0 bare root stock from local seed origins.

2.3 ESTABLISHMENT

The Fairfax Lake experimental site was prepared in late-May 1979, then seeded and fertilized in early July of the same year. The seed mixes were hand-broadcast and then lightly raked into the soil. All legume seeds were dry innoculated with the appropriate Rhizobium species immediately before seeding. After seeding, fertilizer was broadcast to supply 61.6 kg/ha N, 17.1 kg/ha P, and 16.8 kg/ha S - as determined by soils analyses.

Trees were planted at Fairfax Lake in early-June of 1980. The lots used were lodgepole pine DE 53-21-76 and white spruce DE 51-25-5-75. The trees were hand-planted using the "hole planting" technique.

Table 2. Agronomic Species Seed Mixtures Tested At Fairfax Lake And Lynx Creek

Trial	Mixture Designation	Species	% (by weight)	% (by P.L.S.)
Fairfax Lake	I (Edson Mix)	creeping red fescue (Boreal)	40	35
		white clover	20	22
		timothy (Climax)	20	37
		crested wheatgrass	20	6
	II (Bow/Crow Mix)	creeping red fescue (Boreal)	40	20
		white clover	12	8
		timothy (Climax)	24	25
		Canada bluegrass	24	47
Lynx Creek	I (Bow/Crow Mix)	creeping red fescue (Boreal)	40	20
		white clover	12	8
		timothy (Climax)	24	25
		Canada bluegrass	24	47
	II (Blairmore Mix)	creeping red fescue (Boreal)	50	27
		alsike clover	10	7
		timothy (Climax)	20	23
		Canada bluegrass	20	43

Site preparation, seeding, and fertilizing at Lynx Creek were carried out in late-June and early-August 1979. The site preparation and seeding technique were the same as discussed previously for Fairfax Lake. The fertilizer application rates used were 67.2 kg/ha N and 27.9 kg/ha K. The trees were planted in late-May 1980. Lodgepole pine DB 6-4-5-76 and white spruce DB 7-5-5 lots were used. The same planting method as described for Fairfax Lake was used.

2.4 ASSESSMENTS

Grass-legume performance assessments were carried out as follows. In the first year (1980), total ground cover production, seedling density per species, and total seedling density were estimated. In subsequent years the above-ground biomass is also to be estimated annually. Details on methodology and sampling for the above are given in Table 3.

Tree performance estimates will be made in the second and subsequent years. Assessments are to include total height, diameter, and survival. These assessment techniques are outlined in greater detail in Table 4.

Erosion was described qualitatively (a rating from none to extreme).

3.0 RESULTS AND DISCUSSION

Since no tree performance assessments were planned during 1980, the following section deals solely with the performance of the agronomic grass-legume mixtures and application rate treatments at the end of the first growing season. In analyzing the data, the tree species factor was not used and the experiments were treated as two factor (seed mix and mix application rate) factorials with six rather than three replicates.

Table 3. Grass-Legume Performance Assessment Methodology And Sampling.

Parameter	Methodology	Sampling Intensity
Total ground cover production	Ocular estimate made using a 0.5 m X 0.5 m quadrat with a grid of 100 subplots. Number of filled subplots were counted and the partially-filled were pooled and counted. Cover expressed as the percentage of filled subplots.	Average based on five subsamples per plot.
Plant density per species	Count of number of plants per species in a 0.25 m X 0.25 m quadrat. Results reported on a 1 m^2 basis.	Average based on five subsamples per plot.
Total plant density	Sum of seedling density per species data discussed above. Results reported on a 1 m^2 basis.	Average based on five subsamples per plot.
Above-ground biomass (dry matter production)	Oven-dry weight of an above-ground clipping of all living plant materials. Clipping taken at a 1 cm height within a 0.5 m X 0.5 m quadrat.	Average based on five subsamples per plot.

Table 4. Tree Performance Assessment Methodology And Sampling.

Parameter	Methodology	Sampling Intensity
Total height	Measurement of the height of each sample tree (from root collar to apex). Results to be reported as the annual height increment.	Ten permanent sample trees per plot. However, each additional surviving tree in the plot will also be monitored as possible replacement datum in the event of mortality in the permanent sample individuals.
Diameter	Measurement of the diameter of each sample trees (2.5 cm above the root collar). Results to be reported as the annual diameter increment.	Ten permanent sample trees per plot.
Survival	A count of the number of living sample trees. Results to be reported as a percentage.	Ten permanent sample trees per plot.

The ground cover data for the Fairfax Lake trial is presented in Table 5. Seed mixtures had no significant effect of on the production of ground cover. However, there was a significant difference between applications rates for each of the mixtures.

Seed mixture treatments did not affect the ground cover at Lynx Creek. For each mixture the 8.4 and 16.8 kg/ha application rates produced similar amounts of cover which were significantly different from the 0.0 and 28.0 kg/ha rates.

There was no significant effect of seed mixture on the total plant density in either trial (Table 6). In both experiments there was a significant total plant density effect with seeding rate.

The species density data is presented in Appendix II.

Erosion on all plots on both sites was non-existent or very minor.

4.0 Conclusion

On the basis of first growing season results the following conclusions may be made:

i) In the Fairfax Lake experiment, the amount of ground cover produced and the total seedling density differed by seed mixture application rate.

ii) In the Lynx Creek experiment, the amount of ground cover produced by the 8.4 and 16.8 kg/ha seed mixture application rates was not different for either seed mixture. However, ground cover for the 0.0 and 28.0 kg/ha rates for both mixtures were significantly lower and higher respectively.

iii) In the Lynx Creek experiment, the total seedling density differed by seed mixture application rate for both mixture treatments.

iv) The erosion was minimal in both experiments.

Table 5. Ground Cover Production At The End Of The First Growing Season - Fairfax Lake And Lynx Creek Trials

Trial	Mix	Ground Cover (%) By Seed Mixture Application Rate (kg/ha)			
		0.0[1]	8.4	16.8	28.0
Fairfax Lake	I (Edson Mix)	3.0 a	17.9 b	24.6 c	28.8 d
	II (Bow/Crow Mix)	2.9 a	15.1 b	26.9 c	21.2 d
Lynx Creek	I (Bow/Crow Mix)	7.2 a	21.9 b	23.0 b	28.8 c
	II (Blairmore Mix)	5.3 a	15.6 b	17.1 b	21.2 c

Means followed by the same letter within a row are not significantly different at the 5% level in Duncan's New Multiple Range Test

[1]The occurrence of ground cover at the 0.0 kg/ha application rate is largely to natural regeneration in some of the plots. There may have also been some effect from seed drift.

Table 6. Agronomic Grass-Legume Total Plant Density - Fairfax Lake and Lynx Creek Trials

Trial	Mix	Agronomic Grass-Legume Total Plant Denisty ($plants/m^2$) By Seed Mixture Application Rate (kg/ha)			
		0.0	8.4	16.8	28.0
Fairfax Lake	I (Edson Mix)	0.0 a	78.4 b	104.0 c	131.2 d
	II (Bow/Crow Mix)	8.0 a	71.2 b	88.7 c	151.5 d
Lynx Creek	I (Bow/Crow Mix)	9.1 a	94.9 b	169.6 c	220.5 d
	II (Blairmore Mix)	11.7 a	83.7 b	149.9 c	251.2 d

Means followed by the same letter within a row are not significantly different at the 5% level in Duncan's New Multiple Range Test

APPENDIX I

APPENDIX 1. Characteristics of the grass-legume species (used in the Fairfax Lake and Lynx Creek trials) which reflect their value for erosion control and suitablility for use with trees.

Species	Form	Growth Habit	Persistance	Competitive Ability	Erosion Control Value
Alsike clover	30-60 cm high (Budd and Best, 1969), long, thin stems which lie flat to the ground (Elliott and Pankiw 1972); prostrate (Anon., 1977)	tillers profusely from crown (Elliott and Pankiw 1977); non-creeping (Smoliak et al, 1975)	two-three years (Curtis, 1975); short-lived (Anon., 1979)	establishes quickly but is not competive with faster-growing herbage (Elliott and Pankiw, 1972); not competitive with tall-growing grasses but otherwise initially tends to dominate stand (Anon., 1977)	not initially good for erosion control (Elliott and Pankiw, 1972)
Canada blue-grass	erect or rarely decumbent (Best et al, 1971); low-growing (Hafenrichter et al, 1968)	strongly sod-forming (Hafenrichter et al, 1968)	excellent (Curtis, 1975); long-lived (Watson et al, 1980)	very competitive (Hafenrichter et al, 1968)	recommended for cover and erosion control (Hafenrichter et al, 1968)
Creeping red-fescue	tufted, erect grass (Best et al, 1971)	creeping-rooted (Smoliak et al, 1975); extensive, fibrous root system (Elliott and Baenziger, 1977)	excellent (Curtis, 1975)	forms heavy turf with vigorous roots (Smoliak et al, 1975); species has uniform, dense growth (Holmes et al, 1976); rated as moderate-high (Elliott and Baenziger, 1977); some members of genus are allelopathic (Fisher, 1980)	excellent (Elliott and Baenziger, 1977); recommended for erosion control (Hafenrichter et al, 1968)
Crested wheat-grass	tall, stemmy grass (Hafenrichter et al, 1968)	bunch grass (Knowles and Buglass, 1971)	excellent (Curtis, 1975); extremely long-lived (Smoliak et al, 1975); persists as long as 30 years (Hafenrichter et al, 1968)	young stands not competitive while old stands compete well (Knowles and Buglass, 1971)	recommended for soil cover (Anon., 1971); not recommended alone for erosion control (Hafenrichter et al, 1968)
Timothy	tall, tufted grass (Budd and Best, 1969)	bunch grass with fibrous root system (Watson et al, 1980)	excellent (Curtis, 1975); if species does not reseed naturally, it may be short-lived (Anon., 1971)	moderately competitive (Hafenrichter et al, 1968)	recommended for ground cover (Hafenrichter et al, 1968); medium value for erosion control (Watson et al, 1980)
White clover	decumbent (Anon., 1977)	creeping, reproduces by stolons (Smoliak et al, 1975)	excellent (Curtis, 1975); 2-3 years (Anon., 1977) to as long as 5 + years (Smoliak et al, 1975	poor (Anon., 1977)	not recommended for soil cover, poor erosion control value on slopes (Anon., 1971)

APPENDIX II

Seedling Density Per Species (By Mix) For Fairfax Lake Trials

Seed Mix Application Rate (kg/ha)	Seedling Density Per Species ($\#/m^2$) By Mix; Numbers In Paratheses Are Species Estimated Establishment (% by PLS applied)							
	Creeping Red Fescue		White Clover		Timothy		Crested Wheatgrass / Canada Bluegrass	
	I	II	I	II	I	II	I	II
8.4	22.4 (7.4)	8.0 (2.6)	16.0 (8.5)	26.1 (23.0)	37.3 (11.9)	25.6 (6.8)	2.7 (3.4)	5.8 (0.8)
16.8	16.5 (2.7)	19.2 (3.2)	42.1 (11.1)	23.5 (10.4)	42.7 (6.8)	37.9 (5.0)	2.7 (1.7)	8.0 (0.6)
28.0	13.2 (1.3)	22.3 (2.2)	65.1 (10.3)	42.1 (11.1)	48.5 (4.6)	71.5 (5.7)	1.1 (0.6)	13.9 (0.6)

Seedling Density Per Species (By Mix) For Lynx Creek Trials

Seed Mix Application Rate (kg/ha)	Seedling Density Per Species (#/m^2) By Mix; Numbers In Paratheses Are Species Estimated Establishment (% by PLS applied)							
	Creeping Red Fescue		White / Alsike Clover		Timothy		Canada Bluegrass	
	I	II	I	II	I	II	I	II
8.4	33.1 (11.0)	34.7 (9.1)	10.7 (9.4)	10.7 (11.3)	44.8 (11.9)	34.6 (11.0)	0.0 (0.0)	0.0 (0.0)
16.8	71/2 (11.8)	99.7 (13.0)	19.7 (8.7)	11.7 (6.2)	87.5 (11.6)	64.5 (10.3)	0.0 (0.0)	3.2 (0.3)
28.0	58.7 (5.8)	72.5 (5.8)	27.2 (7.2)	17.0 (5.4)	122.1 (9.7)	88.0 (8.4)	1.6 (0.1)	3.2 (0.2)

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